


# **The relationship between wealth and health**

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| Tiivistelmä – Referat – Abstract<br><br><p>The thesis is about the relationship between health and wealth. The goal is to show that they are connected to each other, and that improving health can lead to improve of wealth.</p> <p>The first part discusses the effect of health on wealth and vice versa. It shows that better wealth is connected to better health and health increase lead to the wealth increase.</p> <p>Then there is a theoretical model by Grossman (1972) and which was modified by Jacobson (2000). The model shows that the health is seen as a stock and that individual can invest into the health during the lifetime. The model shows also the change, when there is a family without children (partners can invest into each other's health) and the family with a child (parents invest into child's health). The wage and education effect is shown and developed by Grossman (1972). The increase in wage leads to increase in health, individual has more money to visit the doctors. The increase in education also leads to increase in health, but in this case individual gets more information on healthy lifestyle and follows it.</p> <p>The literature review shows how education, social status, early childhood, family and nutrition affect the health. Better educated have better health and higher income. An additional year of education increases the life. Lower socioeconomic status increases the probability of consuming unhealthy goods and being less educated. The subjective social status affects the childhood, the mental health and the income. Family plays a crucial role: the mother's health, parents education, family's socioeconomic status effect the health of a child and the future income. The low birth weight, mental health problems in childhood and bad nutrition lead to problems in health in the future and lower income.</p> <p>When the connection between health and wealth, and factors affecting the health are known, it is easier to implement policies to increase the total health and wealth. The healthy individual is more productive and it leads to economic growth, what is another topic and also widely discussed.</p> |  |  |
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## 1. Introduction

There have been many researches founding out that rich people expected to live longer than the poorer. In 1980 men in the United States who had income in the top 5% of distribution lived 25% longer than men with the income in the bottom 5%. The recent findings in Britain show the difference in life expectancy between the top and bottom social classes has increased from five to nine years (Deaton, 2016). Indeed socioeconomic status, education, wealth, race, place of the residence and social class are related to mortality and morbidity. Healthier people are better workers: they work harder and more intelligently. Healthier students have higher cognitive functioning, what helps them to perform better at the school and give the possibility to get a higher social status later on.

Most of the public health literature has a strong negative view that the different groups of people are treated differently within the system and has skeptical view of the value of medical care. McKeown (1979) concluded that rising living standards, like housing and nutrition, lead to the increasing of life expectancy. Robert Fogel (1997) also found out that the nutrition is important in the process of economic development and growth. (Deaton, 2016). So, here I will not discuss the effect of race, place of the residence and the access to health care; I will focus mostly on health and wealth relations and the factors like education, family and early childhood.

The relationship between health and wealth is called “gradient”: the health improves when the income grows, and the poor has worse health than the rich, what means the higher the gradient the better the health. Poor health decreases the time available for working and decreases the earnings, at the same time it increases medical expenses, all of these lead to even poorer life than before. I believe that increasing the health is one way to increase the wealth.

Candeias (2016) studied the effect of diabetes on the economic growth. The number of people having diabetes is rising. In 2010 around 11.6% of the total health expenditures in the world were spent on diabetes. Candeias writes: “Diabetes, and other preventable non-communicable diseases, can lead to increased absenteeism and reduced productivity while at work, inability to work as a result of disease-related disability, and lost productive capacity due to early mortality and exclusion from the workplace to take care of sick family members.”

Candeias (2016) concludes that preventing diabetes will help to prevent other diseases, like cardiovascular diseases and cancer, and the households can spend more money on other goods and services.

In this paper the next section will discuss the relation between wealth and health and how do they affect each other. Then there is a theoretical model developed by Michael Grossman in 1972 and modified by Lena Jacobson in 2000. Also Grossman showed how the increase in wage and education change the health stock. The forth section is based on empirical findings of other researches that show how early childhood and education affect the health. And for the last are conclusions.

## **2. The relation between health and wealth**

James P. Smith (1999) made calculations using data from Panel Study of Income Dynamics (PSID). His researches are based on the data from the United States of America. He made a table (Table 1) for different age groups and 3 different years (1984, 1989, 1994), where he showed the correlation between self-reported general health status and income (in 1996 dollars). He noticed that those in excellent health in 1984 have 74 percent more wealth than respondents in fair or poor health do. This difference in income is also related to schooling, “median incomes of 1984 college graduates were \$77 000 compared to \$ 28 000 among high school dropouts – virtually the same as the income gradient from excellent to poor health.”(Smith, 1999).

According to Smith, changes in health lead to changes in income. Among those in the age group 35-44, who reported excellent health in 10 years (from 1984 to 1994) the medium income almost increased by \$100 000, at the same time the income of those who reported fair or poor health increased only by less than \$10 000. So, if the person’s self-estimated health increased from 1984, his or her income also increased.

The other factors which influence health are risk behaviors – like smoking, eating unhealthy food, drinking alcohol etc. These risk behaviors are more common in lower socioeconomic groups. For example, Marmout (1999) has found that the percentage of those with lower incomes or less education smoking is higher than of those who are well educated or earn more. In 1995, 40 percent

of men who had not studied in a high school smoked, while only 14 percent of male college graduates smoked. Similar health patterns exist for other risk behaviors.

It is also important to mention that periods of poor health in the middle age has a negative impact on retirement. If the earnings are reduced in the middle age, it will lead to reducing of the pension and social benefits later on. Smith (1999): “Since health status is positively correlated even across quite distant ages, a correlation of retirement income and current health may flow from past health to current retirement income”.

**Table 1**

**Median Wealth by Self-Reported 1984 Health Status**

| <i>Age Group</i> | <i>1984</i> | <i>1989</i> | <i>1994</i> |
|------------------|-------------|-------------|-------------|
| All Households   |             |             |             |
| Excellent        | 68.3        | 99.3        | 127.9       |
| Very Good        | 66.3        | 81.9        | 90.9        |
| Good             | 51.8        | 59.6        | 64.9        |
| Poor             | 39.2        | 36.0        | 34.7        |
| 25-34            |             |             |             |
| Excellent        | 28.5        | 51.5        | 84.3        |
| Very Good        | 19.5        | 34.7        | 50.1        |
| Good             | 10.5        | 17.2        | 28.2        |
| Fair/Poor        | 0.9         | 3.1         | 10.4        |
| 35-44            |             |             |             |
| Excellent        | 100.1       | 150.1       | 194.7       |
| Very Good        | 81.1        | 96.3        | 117.5       |
| Good             | 49.5        | 45.3        | 83.5        |
| Fair/Poor        | 23.8        | 15.5        | 32.4        |
| 45-54            |             |             |             |
| Excellent        | 164.2       | 198.3       | 255.8       |
| Very Good        | 132.1       | 176.2       | 186.9       |
| Good             | 87.8        | 76.9        | 97.1        |
| Fair/Poor        | 59.7        | 61.6        | 69.4        |

Source: Smith JP, Healthy Bodies and Thick Wallets: The Dual Relation between Health and Economic Status, 1999

## 2.1 The Effect of Health on Wealth

As was mentioned before, health has an important influence on wealth, if the person experience poor health it may reduce the savings and the current income, at the same time it may increase out-of-pocket savings. Health is a stock, which has potential effects on future income, consumption and medical expenses.

Smith (1999) made a table (Table 2) using the data from Health and Retirement Survey (HRS) and from the Asset and Health Dynamics of the Oldest Old Survey (AHEAD). The table consists of two households, ages 51-61 and ages 70+, and distributions of out-of-pocket medical expenses separately for those who experienced severe, mild or no new chronic diseases. Smith explained that severe conditions were defined as cancer, heart condition, stroke, and disease of the lung. All other onsets defined as mild.

**Table 2**  
**Out-of-Pocket Medical Expenditures**

|   | <i>Percentiles</i>     |                        |                        |                        |                        |                        |                        |
|---|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
|   | <i>10<sup>th</sup></i> | <i>30<sup>th</sup></i> | <i>50<sup>th</sup></i> | <i>70<sup>th</sup></i> | <i>90<sup>th</sup></i> | <i>95<sup>th</sup></i> | <i>98<sup>th</sup></i> |
| <b>HRS (ages 51-61) Between Waves 1-3</b> |                        |                        |                        |                        |                        |                        |                        |
| (severe new chronic)                      | 32                     | 793                    | 1 985                  | 4 399                  | 11 659                 | 17 108                 | 31 601                 |
| (mild new chronic)                        | 49                     | 434                    | 1 072                  | 2 255                  | 6 324                  | 9 489                  | 18 322                 |
| (no new chronic)                          | 22                     | 358                    | 868                    | 1 833                  | 4 774                  | 7 983                  | 15 452                 |
| severe-with H.I.                          | 159                    | 1 003                  | 2 147                  | 4 407                  | 11 564                 | 16 855                 | 28 233                 |
| severe without H.I.                       | 0                      | 143                    | 1 060                  | 4 463                  | 16 503                 | 30 519                 | 64 678                 |
| <b>AHEAD (ages 70+) Between Waves 1-2</b> |                        |                        |                        |                        |                        |                        |                        |
| (severe new chronic)                      | 0                      | 622                    | 1 530                  | 3 150                  | 8 600                  | 16 334                 | 34 188                 |
| (mild new chronic)                        | 0                      | 400                    | 980                    | 1 910                  | 5 681                  | 8 894                  | 14 800                 |
| (no new chronic)                          | 0                      | 255                    | 800                    | 1 800                  | 4 839                  | 8 000                  | 19 008                 |

Source: Smith JP, Healthy Bodies and Thick Wallets: The Dual Relation between Health and Economic Status, 1999

The results show that the expenses with severe new chronic diseases for average 70+ aged individual are almost double compare to the one with no new chronic disease. And in the age group 51-61 the difference in expenses is more than double. And in both age groups 2 percent with new chronic diseases spent more than \$30 000.

Smith argues that these results can be helpful to understand savings behavior that “some current wealth may have been accumulated to deal with today’s health problems”.

The problems in health reduce also the labor supply. In case of family, the spouse can work more and invest into the partner; this can be seen in section 3. But anyway the current health problems may reduce the household income in the retirement period.

Another way when health affects savings is when the individuals want to consume more when they are healthy than during the period when they are sick. So it can be that savings rise if the individual expect himself to get sick.

Smith (1999) also made an empirical model which estimates effects of new chronic health problems on household wealth accumulation and the pathways through which savings effects take place. The data he used was from panel surveys of HRS and AHEAD, he used the ordinary least square regression models and the results are in table 3. The table has 3 columns (dependent variables), which shows “between-wave” (there were several surveys conducted in three different years, and Smith calls these surveys as “waves”) changes in total household wealth, OOP=out-of-pocket medical expenses and total medical expenses. The results are mean estimates.

The table 3 shows that even with the mild onset in ages 51-61 with total medical expenditures \$2 555, and the out-of-pocket expenditures are \$635, the household wealth is lowered by \$3 620. But with the severe onset diseases, when the out-of-pocket medical expenditures are not yet that high, the wealth is lowered by \$16 846. The change in wealth is even more dramatic for the household with above median income, the household wealth is lowered by \$25 371. There are also results showing that health insurance doesn’t affect much on the incomes lowering, the difference is \$175.



**Table 3**  
**Economic Effects of New Health Onset**

|                       | <i>Wealth</i> | <i>OOP Expenses</i> | <i>Total Medical Expenses</i> |
|-----------------------|---------------|---------------------|-------------------------------|
| HRS                   |               |                     |                               |
| Mild onset            | -3 620        | 635                 | 2 555                         |
| Severe onset          | -16 846       | 2 266               | 28 963                        |
| AHEAD                 |               |                     |                               |
| Any onset             | -10 481       | 1 026               | NA                            |
| HRS severe onset only |               |                     |                               |
| Below median income   | -11 348       | 2 439               | 29 829                        |
| Above median income   | -25 371       | 2 014               | 28 085                        |
| AHEAD any onset       |               |                     |                               |
| Below median income   | -4 427        | 915                 | NA                            |
| Above median income   | -17 040       | 1 101               | NA                            |

Source: Smith JP, Healthy Bodies and Thick Wallets: The Dual Relation between Health and Economic Status, 1999

Because there was not enough data available for AHEAD, there is no information for mild and severe onset separated. The table 3 shows that any disease lows the income by \$10 481. There is no information on total medical expenditure in AHEAD, that's why Smith put NA in the column. In case of households ages 70+ the income is also has a dramatic lowering for the ones with above median income - \$17 040.

Because table 3 doesn't show the reasons behind the income lowering, except the health conditions, Smith made calculations using "empirical models of the alternative pathways though which wealth accumulation can change – out-of-pocket and total medical expenses, changes in labor supply and household income, changes in bequest intentions, and changes in mortality expectations. Three waves of HRS and two waves of AHEAD were used with separate models estimated for changes observed between each survey wave". Table 4 shows the results.

From the table 4 can be seen that the out-of-pocket medical expenses are over \$1 600, what is low enough compare to the total medical expenses. So the out-of-pocket expenses are not the main reason for the low income. When the new health problem is severe – the change in weekly hours is

about 4 hours per week and a 15 percent point decline in the probability of staying at work. And there is no evidence if the person returns to normal weekly hours. The change in own earnings is lowered by around \$2 600. The table 4 also shows that with new health “shocks” the person also changes the expectation in probability of living to 75.

**Table 4**

**Pathways of Effects of New Health Events in HRS Survey**  
(t statistics in parentheses)

| <i>Type of Health Onset</i> | <i>Out-of-Pocket Medical Costs</i> |              | <i>Total Medical Costs</i> |               | <i>Change in Probability of Living to 75</i> |               |
|-----------------------------|------------------------------------|--------------|----------------------------|---------------|--|---------------|
|                             | <i>W2-W1</i>                       | <i>W3-W2</i> | <i>W2-W1</i>               | <i>W3-W2</i>  | <i>W2-W1</i>                                 | <i>W3-W2</i>  |
| Major 1-2                   | 1 608 (11.3)                       | 792 (3.09)   | 18 299 (20.0)              | 11 712 (5.31) | -6.59 (5.66)                                 | -2.88 (1.96)  |
| Minor 1-2                   | 181 (1.76)                         | 308 (1.68)   | 230 (0.35)                 | 2 191 (1.38)  | -1.75 (2.13)                                 | -0.207 (0.21) |
| Major 2-3                   | NA                                 | 1 699 (7.33) | NA                         | 23 637 (11.8) | NA   | -5.97 (4.46)  |
| Minor 2-3                   | NA                                 | 677 (3.67)   | NA                         | 4 534 (2.85)  | NA   | -0.91 (0.88)  |

| <i>Type of Health Onset</i> | <i>Change in Weekly Hours</i> |              | <i>Probability of Staying at Work</i> |              | <i>Change in Own Earnings</i> |
|-----------------------------|-------------------------------|--------------|---------------------------------------|--------------|-------------------------------|
|                             | <i>W2-W1</i>                  | <i>W3-W2</i> | <i>W2-W1</i>                          | <i>W3-W2</i> | <i>W3-W1</i>                  |
| Major 1-2                   | -4.13 (6.09)                  | 0.28 (0.38)  | -0.15 (7.08)                          | -0.06 (2.24) | -2 639 (2.96)                 |
| Minor 1-2                   | -1.45 (2.99)                  | -0.54 (1.04) | -0.05 (3.40)                          | -0.02 (1.12) | -1 638 (2.57)                 |
| Major 2-3                   | NA                            | -3.92 (6.01) | NA                                    | -0.16 (7.67) | NA                            |
| Minor 2-3                   | NA                            | -1.19 (2.28) | NA                                    | -0.04 (2.67) | NA                            |

Source: Smith JP, Healthy Bodies and Thick Wallets: The Dual Relation between Health and Economic Status, 1999

At the same time Smith agreed that these results create a puzzle, the out-of-pocket medical expenditures are not that high compare to the total medical expenditures, and the change in income own earnings is not that big, but the total change in wealth, shown in table 3, can be dramatic. Smith explained that it can be caused by “measurement issues that understate medical costs or household income changes, or that overstate changes in household wealth. Out-of-pocket medical costs may well understate the full financial costs of an illness. There are expenditures associated with an illness of a family member – transportation, reconfiguration of home care environments, and so on – which people may not think of as medical costs and are often not reimbursed. Although

household wealth is notoriously difficult to measure, it is not apparent why any errors should be systematically related to health events unless estimates of wealth shift from optimistic to pessimistic with the onset of an illness.”

At the same time with the reduction of income, there is possibility for rising consumption of household; Lillard and Weiss (1993) found out that the marginal utility of consumption increases in periods of poor health. Also people may “invest” in their siblings or consume at a very high rate.

## 2.2 The Effect of Wealth on Health

Smith (2005) estimated a probit model using HRS survey data, where he used as variables education, parental health and education, wealth and health during childhood. The results can be found in Table 5.

**Table 5**

**Probits predicting the future onset of major and minor chronic diseases**

| <i>SES Indicator</i>                   | <i>Major condition</i> |                   | <i>Minor condition</i> |                   |
|--|------------------------|-------------------|------------------------|-------------------|
|  | <i>Estimate</i>        | <i>Chi square</i> | <i>Estimate</i>        | <i>Chi square</i> |
| Income                                 | 0.0456                 | 0.93              | -0.0044                | 0.00              |
| Wealth                                 | -0.0040                | 1.60              | -0.0001                | 0.00              |
| Change in stock wealth                 | -0.0008                | 1.06              | 0.0003                 | 0.75              |
| 12-15 years schooling                  | -0.0783                | 2.66              | -0.0527                | 1.38              |
| College or more                        | -0.0483                | 0.52              | -0.0927                | 2.33              |
| Health excellent or very good as child | -0.0870                | 4.68              | 0.0042                 | 0.01              |
| Not poor during childhood              | -0.0949                | 6.31              | 0.0155                 | 0.20              |
| Mother's education                     | 0.0028                 | 0.18              | 0.0004                 | 0.00              |
| Father's education                     | -0.0018                | 0.09              | -0.0046                | 0.72              |
| Father alive                           | -0.1362                | 1.34              | -0.2001                | 3.32              |
| Age of father at death                 | -0.0001                | 0.00              | -0.0014                | 0.88              |
| Mother alive                           | -0.0743                | 0.49              | -0.2465                | 6.51              |
| Age of mother at death                 | -0.0002                | 0.09              | -0.0028                | 4.60              |

Source: Smith JP (2005) Unraveling the SES-Health Connection. RAND

From the Table 5 can be seen that Smith found that for the major onsets, better health and wealth reduce the risk of incurring a serious health onset in 50s. For the minor onsets, parental health reduces the risk of getting new chronic disease in 50s. From the Table 5 it is also seen that the education plays a crucial role for both major and minor onsets.

Smith and Goldman (2002) found out how self-management is related to education. They were analyzing the group of people with diabetes; the people were divided according to their education – post-graduate degree, college graduate/some college, and high school degree/some education. The findings were that the ones with post-graduate degree were much more willing to take care of themselves. The estimated numbers can be seen in Table 6.

**Table 6**

**Educational Differences in Treatment Adherence at Diabetes Control and Complications Trial baseline**

| <i>Measure of adherence</i>   | <i>Post-graduate degree</i> | <i>College graduate/some college</i> |  | <i>HS degree/some secondary</i> |
|---|-----------------------------|--------------------------------------|--|---------------------------------|
|   |                             |                                      |  |                                 |
| Number of times self-monitored blood glucose per week               | 8.8                         | 7.7                                  |  | 6.7                             |
| Missed insulin injection at least once in past month (%)            | 4.3                         | 6.0                                  |  | 9.2                             |
| Did not follow insulin regimen at least once in past month (%)      | 15.7                        | 25.2                                 |  | 26.6                            |
| Did not self-test blood or urine at least one day in past month (%) | 66.1                        | 74.1                                 |  | 77.2                            |
| Minutes of very hard exercise per week                              | 58.1                        | 49.6                                 |  | 19.7                            |
| Currently smoking cigarettes (%)                                    | 16.5                        | 19.2                                 |  | 40.8                            |

Source: Goldman D and Smith JP (2002) Can patient self-management help explain the SES health gradient. *Proceedings of the National Academy of Sciences*, 99(16): 10929-10934

When the common treatment regime was made for all the groups, the less educated benefited more from treatment (the treatment was beneficial for all). Smith (2005): “A differential ability to adhere to beneficial albeit complicated medical regimens appears to be one reason for the association between education and health outcomes for the chronically ill.” The results of Goldman and Smith

(2002), when the common treatment regime was enforced to the all educational groups, can be found in Table 7.

**Table 7**

**Educational Differences in Treatment Impact for Diabetics**

| Group                             | <i>Glycosolated hemoglobin</i> |                              |                                 |
|-----------------------------------|--------------------------------|------------------------------|---------------------------------|
|                                   | <i>College</i>                 |                              |                                 |
|                                   | <i>Post-graduate degree</i>    | <i>graduate/some college</i> | <i>HS degree/some secondary</i> |
| Conventional therapy only (n=495) |                                |                              |                                 |
| Baseline                          | 8.42                           | 8.76                         | 8.96                            |
| End of study                      | 8.88                           | 9.08                         | 9.59                            |
| Difference                        | 0.46                           | 0.32                         | 0.63                            |
| Intensive treatment only (n=490)  |                                |                              |                                 |
| Baseline                          | 8.04                           | 8.86                         | 8.93                            |
| End of study                      | 7.18                           | 7.30                         | 7.43                            |
| Difference                        | -0.85                          | -1.56                        | 1.51                            |
| Treatment effect                  | -1.31                          | -1.88                        | 2.14                            |

Source: Goldman D and Smith JP (2002) Can patient self-management help explain the SES health gradient. *Proceedings of the National Academy of Sciences*, 99(16): 10929-10934

Education may also help to train people for decision making and problem-solving, to get information about healthy lifestyle and possible treatments. Also education may have biological effects on the brain.

The other important factor which affects health in the future is the childhood. Barker (1997) wrote that the health of an embryo has an effect of the future health problems. For example, the lack of nutrition and oxygen for an embryo leads to the low birth weights and to the disproportionate growth in different parts of the body and these can lead to the coronary heart diseases 50 or 60 years later.

Another effect on health during lifetime is stress related to the job and family. When the person is under the stress or threat, the level of adrenaline can increase which allows body to perform at higher levels. Increased adrenaline provides simultaneous challenges for blood pressure, heart rate

and the immune system. In the short-run this changes are not dangerous, but when the stress occurs too often, the results can lead to disease, like high blood pressure, diabetes or cholesterol.

Income inequality is also one of the factors which affect health. A common idea is that the social inequality raises levels of psycho-social stress which negatively affects adrenaline and immunological processes. In industrial countries the material level matters less than the fact being at the bottom in the social ranking. (Smith, 1999).

### 3. Theoretical Model

The model is developed by Michael Grossman (1972) and modified by Lena Jacobson (2000).

Let the individual's utility function be:

$$U = U(H_t, Z_t), \quad (1)$$

where  $H_t$  is the stock of health in period  $t$ , and  $Z_t$  is consumption of other goods. The length of life is fixed here and it is an endogenous variable.

The individual's stock of life will decrease during a lifetime, but the person can invest in health:

$$\partial H_t / \partial t = I_t - \delta_t H_t, \quad (2)$$

where  $I_t$  is gross investment in health and  $\delta_t$  is the rate of depreciation rate of health during  $t$  period. The individual produces gross investment in health,  $I_t$ , and the other commodities,  $Z_t$ , according to a set of production functions:

$$I_t = I_t(M_t, h_{t,H}; E_t) \quad (3)$$

and

$$Z_t = Z_t(X_t, h_{t,Z}; E_t), \quad (4)$$

where  $M_t$  is medical care,  $X_t$  is the market goods,  $h_{t,H}$  and  $h_{t,Z}$  are time inputs, and  $E_t$  is a stock of human capital. The change in human capital changes the efficiency of the production process in the nonmarket sector of the economy.

The individual stock of health over time is expressed by:

$$\frac{\partial W_t}{\partial t} = rW_t + \omega_t h_{t,\omega} + B_t - p_t M_t - v_t X_t, \quad (5)$$

where  $B_t$  is transfers and  $W_t$  is wealth,  $p_t$  and  $v_t$  are the prices of  $M_t$  and  $X_t$ ,  $\omega_t$  is the wage rate,  $h_{t,\omega}$  is time in market work and  $r$  is the market interest rate.

Health has an effect on market income through the effect on wage and the time in market work. Jacobson assume that wage rate ( $\omega_t$ ) depends on health capital ( $H_t$ ) and human capital ( $E_t$ ), so it can be thought as “labor market earnings rate of return on human capital”.

The total time available is shaped by time spent sick ( $h_{t,S}$ ), time in market work ( $h_{t,\omega}$ ), time spent in producing health ( $h_{t,H}$ ) and time spent in other commodities ( $h_{t,Z}$ ):

$$\Omega = h_{t,S} + h_{t,\omega} + h_{t,H} + h_{t,Z}. \quad (6)$$

The model assumes that  $h_{t,S}$  is inversely related to the stock of health,  $\partial h_{t,S} / \partial H_t < 0$ . If  $\Omega$  would be measured in number of days in a year, the  $h_t$  would be the number of healthy days:

$$h_{t,S} = \Omega - h_t. \quad (7)$$

Grossman explains that the time which is spent on a visit to a doctor is not a sick time, but the time invested in health.

The individual can spend his wealth partly on market goods, partly on nonmarket production time, and part is lost due to sickness. The problem is to maximize lifetime utility by choosing the paths of the control variables  $M_t$  and  $Z_t$ :

$$Max. U = \int_t^T u(H_t, Z_t) e^{-\theta t} dt$$

$$s.t. \frac{\partial H_t}{\partial t} = I_t - \delta_t H_t$$

$$\frac{\partial W_t}{\partial t} = rW_t + \omega_t h_{t,\omega} + B_t - p_t M_t - v_t X_t$$

$$\Omega = h_{t,S} + h_{t,\omega} + h_{t,H} + h_{t,Z}$$

$$H(0) = H_0, W(0) = W_0, H_0 \text{ and } W_0 \text{ given}$$

$$H(T) = H_t \leq H_{min}, W(T) = W_t \geq 0, W_T^* \lambda_{T,W} = 0$$

T free

$$\text{and } X_t, M_t \geq 0 \text{ for all } t \in [0, T] \quad (8)$$

where  $\theta$  is individual's subjective rate of time preference,  $\frac{\partial H_t}{\partial t}$  and  $\frac{\partial W_t}{\partial t}$  are the equations of motion for the state variables, H and W, T is the time of death and t is the present time.

To solve the problem the Hamiltonian is formed:

$$H = u(H_t, Z_t)e^{-\theta t} + \lambda_{t,H}[I_t - \delta_t H_t] + \lambda_{t,W}[rW_t + \omega_t h_{t,\omega} + B_t - p_t M_t - v_t X_t],$$

From Hamiltonian the interior solution is found and the Lagrangian is formed:

$$L = u_t(H_t, Z_t)e^{-\theta t} + \lambda_{t,H}[I_t - \delta_t H_t] + \lambda_{t,W}[rW_t + \omega_t h_{t,\omega} + B_t - p_t M_t - v_t X_t] + \varphi_t[\Omega - h_{t,S} - h_{t,\omega} - h_{t,H} - h_{t,Z}], \quad (9)$$

where  $\varphi_t$  is the lagrange multiplier for the time restriction,  $\lambda_{t,W}$  and  $\lambda_{t,H}$  are costate variables.  $\lambda_{t,H}$  is the increase in lifetime utility if health in period  $t$  is increase by one unit of health capital. When the budget is binding  $\lambda_{t,W}$  is high. According to Jacobson (2000)  $\lambda_{t,W}$  and  $\varphi_t$  can be considered as measures of economic and time stress.

F.O.C (interior solution):

$$\partial L / \partial M_t = \partial L / \partial X_t = 0 \quad \text{for all } t \in [0, T]$$

$$\partial L / \partial \varphi_t = 0$$

$$\partial H_t / \partial t = \partial L / \partial \lambda_{t,H} \quad \text{equation of motion for the state variable } H \quad (10)$$

$$\partial W_t / \partial t = \partial L / \partial \lambda_{t,W} \quad \text{equation of motion for the state variable } W$$

$$\partial \lambda_{t,H} / \partial t = -\partial L / \partial H_t \quad \text{equation of motion for } \lambda_H$$

$$\partial \lambda_{t,W} / \partial t = -\partial L / \partial W_t \quad \text{equation of motion for } \lambda_W$$

From these F.O.C. follow:

$$\partial L / \partial M_t = \lambda_{t,H} \partial I_t / \partial M_t - \lambda_{t,W} p_t = 0 \quad (11)$$



since  $I_t = (M_t, h_{t,H}; E_t)$ . Rearranging the equation (11)  $\lambda_{t,H}$  is found:

$$\lambda_{t,H} = \lambda_{t,W} p_t \partial M_t / \partial I_t. \quad (12)$$

To make equation (12) simpler it is assumed that  $p_t \partial M_t / \partial I_t = \pi_t$  what is the effective price of medical care goods and services ( $M_t$ ):

$$\lambda_{t,H} = \lambda_{t,W} \pi_t, \quad (13)$$

and

$$\partial \lambda_{t,H} / \partial t = \partial \lambda_{t,W} / \partial t \pi_t + \lambda_{t,W} \partial \pi_t / \partial t. \quad (14)$$

From equation (13) is seen that when  $\pi_t$  or  $\lambda_{t,W}$  are high,  $\lambda_{t,H}$  will be high too, and it means that the individual's stock of health is low.

$$\partial L / \partial \varphi_t = \Omega - h_{t,S} - h_{t,\omega} - h_{t,H} - h_{t,Z} = 0 \quad (15)$$

$$\partial L / \partial X_t = e^{-\theta t} \partial u_t / \partial Z_t \partial Z_t / \partial X_t - \lambda_{t,W} v_t = 0, \quad (16)$$

where  $Z_t = Z_t(X_t, h_{t,Z}; E_t)$ .

$$\partial L / \partial \lambda_{t,H} = I_t - \delta_t H_t \quad (17)$$

$$\partial L / \partial \lambda_{t,W} = r W_t + \omega_t h_{t,\omega} + B_t - p_t M_t - v_t X_t \quad (18)$$

$$\partial L / \partial H_t = e^{-\theta t} \partial u_t / \partial H_t - \lambda_{t,H} \delta_t + \lambda_{t,W} h_{t,\omega} \partial \omega_t / \partial H_t - \varphi_t \partial h_{t,S} / \partial H_t = -\partial \lambda_{t,H} / \partial t, \quad (19)$$

where  $\omega_t = \omega_t(H_t, E_t)$ ,  $\partial u_t / \partial H_t$  is marginal utility of health capital,  $\partial \omega_t / \partial H_t$  is the marginal effect of health on wage and  $\partial h_{t,S} / \partial H_t$  is the marginal effect of health on the amount of sick time.

From the rearranging equation (19) can be seen that  $\lambda_{t,H}$  is depend on the rate of depreciation, the marginal effect of health on wage and the valuation of time. So, like in equation (14) when the depreciation rate increases,  $\lambda_{t,H}$  will increase and the health stock will decrease. When wage increases the individual will invest more in health and  $\lambda_{t,H}$  will decrease. And the higher valuation of time will increase the investments in health, which also leads to decrease of  $\lambda_{t,H}$ :

$$\partial \lambda_{t,H} / \partial t = \varphi_t \partial h_{t,S} / \partial H_t - e^{-\theta t} \partial u_t / \partial H_t + \lambda_{t,H} \delta_t - \lambda_{t,W} h_{t,\omega} \partial \omega_t / \partial H_t.$$

$$\partial L / \partial W_t = \lambda_{t,W} r = -\partial \lambda_{t,W} / \partial t \quad (20)$$

Since  $\partial L / \partial H_t = -\partial \lambda_{t,H} / \partial t$ , combining the equation (14) and (19):

$$e^{-\theta t} \partial u_t / \partial H_t - \lambda_{t,H} \delta_t + \lambda_{t,W} h_{t,\omega} \partial \omega_t / \partial H_t - \varphi_t \partial h_{t,S} / \partial H_t = -(\partial \lambda_{t,W} / \partial t \pi_t + \lambda_{t,W} \partial \pi_t / \partial t). \quad (21)$$

Putting equation (20) and (13) to equation (21):

$$e^{-\theta t} \partial u_t / \partial H_t - \lambda_{t,W} \pi_t \delta_t + \lambda_{t,W} h_{t,\omega} \partial \omega_t / \partial H_t - \varphi_t \partial h_{t,S} / \partial H_t = \lambda_{t,W} r \pi_t - \lambda_{t,W} \partial \pi_t / \partial t \quad (22)$$

The equation (22) is divided by  $\lambda_{t,W}$ :

$$(e^{-\theta t} / \lambda_{t,W}) \partial u_t / \partial H_t - \pi_t \delta_t + h_{t,\omega} \partial \omega_t / \partial H_t - (\varphi_t / \lambda_{t,W}) \partial h_{t,S} / \partial H_t = r \pi_t - \partial \pi_t / \partial t \quad (23)$$

And now all the  $\pi_t$  parameters are moved to the right side of equation and here is the solution to the maximization problem:

$$(e^{-\theta t} / \lambda_{t,W}) \partial u_t / \partial H_t + h_{t,\omega} \partial \omega_t / \partial H_t - (\varphi_t / \lambda_{t,W}) \partial h_{t,S} / \partial H_t = r \pi_t - \partial \pi_t / \partial t + \pi_t \delta_t, \quad (24)$$

$$(e^{-\theta t} / \lambda_{t,W}) \partial u_t / \partial H_t + h_{t,\omega} \partial \omega_t / \partial H_t - (\varphi_t / \lambda_{t,W}) \partial h_{t,S} / \partial H_t = \pi_t (r - (\partial \pi_t / \partial t) / \pi_t + \delta_t). \quad (25)$$

Equation (25) means that individual will invest in health until the marginal benefit of new health equals the marginal cost of health.

Jacobson (2000): "...the solution shows that  $\lambda_{t,W}$  decreases over time with a rate equal to the rate of interest  $r$ ...the individual is free to borrow and lend capital at each period of time...but  $W_T$  is restricted to be non-negative..."

### 3.1 Family effect

Jacobson (2000) extended Grossman model to show that family also effects on health: the husband can invest in the wife's health (and vice versa), the parents can invest in child's health.

#### 3.1.1 Husband-wife model

The extended model includes the variables for husband,  $m$  (male), and wife  $f$  (female). Basic assumptions are the same like in the first model. The utility function is:

$$U = U(H_m, H_f, Z), \quad (26)$$

where  $H_m$  is health of husband and  $H_f$  is health of wife.

The investment functions for husband,  $I_m$ , and wife,  $I_f$ :

$$I_m = I_m (M_m, h_{Hm,m}, h_{Hm,f}; E_{H,m}, E_{H,f}) \quad (27)$$

and

$$I_f = I_f (M_f, h_{Hf,m}, h_{Hf,f}; E_{H,m}, E_{H,f}), \quad (28)$$

where  $M_m$  and  $M_f$  are medical care for husband and wife,  $h_{Hm,m}, h_{Hm,f}, h_{Hf,m}, h_{Hf,f}$  are time used in the production of health. The first letter means what is produced – husband's or wife's health, the second letter indicates the producer.  $E_{H,m}, E_{H,f}$  are male and female productivity in the health production. Net investments in health now:

$$\partial H_m / \partial t = I_m - \delta_m H_m \quad (29)$$

and

$$\partial H_f / \partial t = I_f - \delta_f H_f, \quad (30)$$

where husband and wife have their own depreciation rate  $\delta$ .

The development of family wealth is:

$$\frac{\partial W}{\partial t} = rW + \omega_m h_{\omega,m} + \omega_f h_{\omega,f} + B - p(M_m + M_f) - vX, \quad (31)$$

where  $\omega_m$  and  $\omega_f$  are the spouses labor market earnings rate of return on human capital, which depend on their health, and level of education and on-the-job trainings.

The total time available is:

$$\Omega = h_{S,i} + h_{\omega,i} + h_{Hf,i} + h_{Hm,i} + h_{Z,i}, \quad i=m,f \quad (32)$$

The problem facing the family is to choose the time path of control variables  $M_m, M_f$  and  $Z$ , in order to maximize lifetime utility:

$$Max. U = \int_t^T u(H_m, H_f, Z) e^{-\theta t} dt$$

$$\text{s.t. } \partial H_m / \partial t = I_m - \delta_m H_m$$

$$\partial H_f / \partial t = I_f - \delta_f H_f$$

$$\frac{\partial W}{\partial t} = rW + \omega_m h_{\omega,m} + \omega_f h_{\omega,f} + B - p(M_m + M_f) - vX$$

$$\Omega = h_{S,i} + h_{\omega,i} + h_{Hf,i} + h_{Hm,i} + h_{Z,i}, \quad i=m,f$$

$$H_m(0), H_f(0), W(0) \text{ given}$$

$$H_m(T) \text{ and/or } H_f(T) \leq H_{min}$$

$$W(T) \geq 0, W_T^* \lambda_T^W = 0$$

$$T \text{ free}$$

$$\text{and } X, M_m, M_f \geq 0 \text{ for all } t \in [0, T]. \quad (33)$$

$T$  is the lifetime of the husband-wife family, the family “dies” when one of the partners reaches  $H_{min}$ .

To solve the problem the Hamiltonian is formed:

$$H = u(H_m, H_f, Z) e^{-\theta t} + \lambda_{Hm} [I_m - \delta_m H_m] + \lambda_{Hf} [I_f - \delta_f H_f] + \lambda_W [rW + \omega_m h_{\omega,m} + \omega_f h_{\omega,f} + B - p(M_m + M_f) - vX],$$

From Hamiltonian the interior solution is found and the Langrangian is formed:

$$L = u(H_m, H_f, Z) e^{-\theta t} + \lambda_{Hm} [I_m - \delta_m H_m] + \lambda_{Hf} [I_f - \delta_f H_f] + \lambda_W [rW + \omega_m h_{\omega,m} + \omega_f h_{\omega,f} + B - p(M_m + M_f) - vX] + \varphi_m [\Omega - h_{S,m} - h_{\omega,m} - h_{Hf,m} - h_{Hm,m} - h_{Z,m}] + \varphi_f [\Omega - h_{S,f} - h_{\omega,f} - h_{Hf,f} - h_{Hm,f} - h_{Z,f}] \quad (34)$$

F.O.C (interior solution):

$$\partial L / \partial M_i = \partial L / \partial X = 0 \quad \text{for all } t \in [0, T]$$

$$\partial L / \partial \varphi_m = \partial L / \partial \varphi_f = 0$$

$$\partial H_m / \partial t = \partial L / \partial \lambda_{Hm} \quad \text{equation of motion for the state variable } H \text{ for husband} \quad (35)$$

$$\partial H_f / \partial t = \partial L / \partial \lambda_{Hf} \quad \text{equation of motion for the state variable } H \text{ for wife}$$

$$\partial W / \partial t = \partial L / \partial \lambda_W \quad \text{equation of motion for the state variable } W$$

$$\partial \lambda_{Hm} / \partial t = -\partial L / \partial H_m \quad \text{equation of motion for } \lambda_{Hm}$$

$$\partial \lambda_{Hf} / \partial t = -\partial L / \partial H_f \quad \text{equation of motion for } \lambda_{Hf}$$

$$\partial \lambda_W / \partial t = -\partial L / \partial W \quad \text{equation of motion for } \lambda_W$$

To make calculations easier to read m and f are substituted by i (i=m,f) in some equations:

$$\lambda_{Hm}[I_m - \delta_m H_m] = \lambda_{Hf}[I_f - \delta_f H_f] = \lambda_{Hi}[I_i - \delta_i H_i]$$

$$M_m = M_f = M_i$$

From the interior F.O.C. follow:

$$\partial L / \partial M_i = \lambda_{Hi} \partial I_i / \partial M_i - \lambda_W p = 0 \quad (36)$$

From equation (36)  $\lambda_{Hi}$  is found:

$$\lambda_{Hi} = \lambda_W p \partial M_i / \partial I_i = \lambda_W \pi_i \quad (37)$$

Like in previous model there is a substitution of  $p \partial M_i / \partial I_i$  by  $\pi_i$ .

$$\partial \lambda_{Hi} / \partial t = \partial \lambda_W \pi_i / \partial t + \lambda_W \partial \pi_i / \partial t \quad (38)$$

$$\partial L / \partial X = e^{-\theta t} \partial u / \partial Z \partial Z / \partial X - \lambda_W v = 0, \quad (39)$$

where  $Z = Z(X, h_{Z,i}; E_{H,m}, E_{H,f})$ .

$$\partial L / \partial \varphi_m = \Omega - h_{S,m} - h_{\omega,m} - h_{Hf,m} - h_{Hm,m} - h_{Z,m} = 0 \quad (40)$$

$$\partial L / \partial \varphi_f = \Omega - h_{S,f} - h_{\omega,f} - h_{Hf,f} - h_{Hm,f} - h_{Z,f} = 0 \quad (41)$$

$$\partial L / \partial \lambda_{Hi} = I_i - \delta_i H_i \quad (42)$$

$$\partial L / \partial W = \lambda_W r = -\partial \lambda_W / \partial t \quad (43)$$

$$\partial L / \partial \lambda_W = rW + \omega_m - h_{\omega,m} + \omega_f h_{\omega,f} + B - p(M_m + M_f) - vX \quad (44)$$

$$\partial L/\partial H_i = e^{-\theta t} \partial u/\partial H_i - \lambda_{Hi} \delta_i + \lambda_W h_{\omega,i} \partial \omega_i/\partial H_i - \varphi_i \partial h_{S,i}/\partial H_i = -\partial \lambda_{Hi}/\partial t, \quad (45)$$

The equations (37) and (38) are set in equation (45):

$$e^{-\theta t} \partial u/\partial H_i - \lambda_W \pi_i \delta_i + \lambda_W h_{\omega,i} \partial \omega_i/\partial H_i - \varphi_i \partial h_{S,i}/\partial H_i = -(\partial \lambda_W \pi_i/\partial t + \lambda_W \partial \pi_i/\partial t) \quad (46)$$

Equation (43) is set to equation (46) and then divided the whole equation by  $\lambda_W$ :

$$(e^{-\theta t}/\lambda_W) \partial u/\partial H_i - \pi_i \delta_i + h_{\omega,i} \partial \omega_i/\partial H_i - (\varphi_i/\lambda_W) \partial h_{S,i}/\partial H_i = r \pi_i - \partial \pi_i/\partial t \quad (47)$$

Then all  $\pi_i$  terms moved to the left, and substituted  $i$  by  $m$  and  $f$ :

$$(e^{-\theta t}/\lambda_W) \partial u/\partial H_i + h_{\omega,i} \partial \omega_i/\partial H_i - (\varphi_i/\lambda_W) \partial h_{S,i}/\partial H_i = r \pi_i + \pi_i \delta_i - \partial \pi_i/\partial t \quad (48)$$

The optimal condition for husband:

$$(e^{-\theta t}/\lambda_W) \partial u/\partial H_m + h_{\omega,m} \partial \omega_m/\partial H_m - (\varphi_m/\lambda_W) \partial h_{S,m}/\partial H_m = \pi_m(r + \delta_m - (\partial \pi_m/\partial t)/\pi_m) \quad (49)$$

and for wife:

$$(e^{-\theta t}/\lambda_W) \partial u/\partial H_f + h_{\omega,f} \partial \omega_f/\partial H_f - (\varphi_f/\lambda_W) \partial h_{S,f}/\partial H_f = \pi_f(r + \delta_f - (\partial \pi_f/\partial t)/\pi_f). \quad (50)$$

In this model the optimal condition, equations (49) and (50), is not valid anymore.

To get the marginal condition equations (49) and (50) are rearranged, the marginal utility of the health is left on the left side and the rest is put on the right side and the expression (49) for husband is divided by the expression (50) for wife:

$$\begin{aligned} (e^{-\theta t}/\lambda_W) \partial u/\partial H_m &= \pi_m(r + \delta_m - (\partial \pi_m/\partial t)/\pi_m) - h_{\omega,m} \partial \omega_m/\partial H_m + (\varphi_m/\lambda_W) \partial h_{S,m}/\partial H_m \\ (e^{-\theta t}/\lambda_W) \partial u/\partial H_f &= \pi_f(r + \delta_f - (\partial \pi_f/\partial t)/\pi_f) - h_{\omega,f} \partial \omega_f/\partial H_f + (\varphi_f/\lambda_W) \partial h_{S,f}/\partial H_f \\ \frac{(e^{-\theta t}/\lambda_W) \partial u/\partial H_m = \pi_m(r + \delta_m - (\partial \pi_m/\partial t)/\pi_m) - h_{\omega,m} \partial \omega_m/\partial H_m + (\varphi_m/\lambda_W) \partial h_{S,m}/\partial H_m}{(e^{-\theta t}/\lambda_W) \partial u/\partial H_f = \pi_f(r + \delta_f - (\partial \pi_f/\partial t)/\pi_f) - h_{\omega,f} \partial \omega_f/\partial H_f + (\varphi_f/\lambda_W) \partial h_{S,f}/\partial H_f}, \end{aligned} \quad (51)$$

the equation (51) is reduced by  $(e^{-\theta t}/\lambda_W)$ , and the marginal condition is:

$$\frac{\partial u/\partial H_m}{\partial u/\partial H_f} = \frac{\pi_m(r + \delta_m - (\partial \pi_m/\partial t)/\pi_m) - h_{\omega,m} \partial \omega_m/\partial H_m + (\varphi_m/\lambda_W) \partial h_{S,m}/\partial H_m}{\pi_f(r + \delta_f - (\partial \pi_f/\partial t)/\pi_f) - h_{\omega,f} \partial \omega_f/\partial H_f + (\varphi_f/\lambda_W) \partial h_{S,f}/\partial H_f}. \quad (52)$$

It means that both partners invest in health until the rate of marginal consumption benefits equals the rate of marginal net effective cost of health capital. The net effective cost of health capital equals the user cost of capital less the marginal investment less the marginal investment benefit of health capital.

The result derived from equation (37) for lifetime utility for health is:

$$\lambda_W = \lambda_{Hm}/\pi_m = \lambda_{Hf}/\pi_f \quad (53)$$

It means that partners will invest in health until the rate of lifetime utility of health to the effective price of health is equal for all family members.

### 3.1.2 The parents-child family

To the previous model a new one variable is added to indicate a child,  $c$ .

The utility function is:

$$U=U(H_m, H_f, H_c, Z) \quad (54)$$

where  $H_c$  is health of child.

Net investments in child's health ( $I_c$ ) are:

$$I_c = I_c(M_c, h_{Hc,m}, h_{Hc,f}; E_{H,m}, E_{H,f}) \quad (55)$$

where  $h_{Hc,m}, h_{Hc,f}$  are parental time invested to child's health.

The total time is:

$$\Omega = h_{\omega,i} + h_{Z,i} + h_{Hm,i} + h_{Hf,i} + h_{c,i} + h_{S,i} + h_{Sc,i} \quad i=m,f \quad (56)$$

where  $h_{Sc,i}$  is time when one of the parents (i) take care of a sick child, and where  $\partial h_{Sc,i}/\partial H_c < 0$  and  $\partial^2 h_{Sc,i}/\partial H_c^2 > 0$ .

The development of family wealth is the same like in the husband-wife model, except that term  $M_c$  is added to describe the medical care of child.

The problem facing the family is to choose the time paths of the control variables  $M_m, M_f, M_c$ , and  $Z$ , in order to maximize lifetime utility:

$$\text{Max. } U = \int_t^T u(H_m, H_f, H_c, Z) e^{-\theta t} dt$$

$$\text{s.t. } \partial H_j / \partial t = I_j - \delta_j H_j \quad \text{for } j=m, f, c$$

$$\frac{\partial W}{\partial t} = rW + \omega_m h_{\omega, m} + \omega_f h_{\omega, f} + B - p(M_m + M_f + M_c) - vX$$

$$\Omega = h_{\omega, i} + h_{Z, i} + h_{Hm, i} + h_{Hf, i} + h_{c, i} + h_{S, i} + h_{Sc, i}, \quad i=m, f$$

$$H_j(0) \quad \text{for } j=m, f, c$$

$$H_j(T) \leq H_{min} \quad \text{for at least one of } j=m, f, c$$

$$W(T) \geq 0, W_T^* \lambda_w(T) = 0$$

T free

$$\text{and } X, M_j \geq 0 \text{ for all } t \in [0, T], j=m, f, c. \quad (57)$$

To solve the problem the Hamiltonian is formed:

$$H = u(H_m, H_f, H_c, Z) e^{-\theta t} + \lambda_{Hm} [I_m - \delta_m H_m] + \lambda_{Hf} [I_f - \delta_f H_f] + \lambda_{Hc} [I_c - \delta_c H_c] + \lambda_w [rW + \omega_m h_{\omega, m} + \omega_f h_{\omega, f} + B - p(M_m + M_f + M_c) - vX],$$

From Hamiltonian the interior solution is found and the Langrangian is formed:

$$L = u(H_m, H_f, H_c, Z) e^{-\theta t} + \lambda_{Hm} [I_m - \delta_m H_m] + \lambda_{Hf} [I_f - \delta_f H_f] + \lambda_{Hc} [I_c - \delta_c H_c] + \lambda_w [rW + \omega_m h_{\omega, m} + \omega_f h_{\omega, f} + B - p(M_m + M_f + M_c) - vX + \varphi_m [\Omega - h_{\omega, m} - h_{Z, m} - h_{Hm, m} - h_{Hf, m} - h_{c, m} - h_{S, m} - h_{Sc, m}] + \varphi_f [\Omega - h_{\omega, f} - h_{Z, f} - h_{Hm, f} - h_{Hf, f} - h_{c, f} - h_{S, f} - h_{Sc, f}]]. \quad (58)$$

F.O.C (interior solution):

$$\partial L / \partial M_j = \partial L / \partial X = 0 \quad \text{for all } t \in [0, T]$$

$$\partial L / \partial \varphi_m = \partial L / \partial \varphi_f = 0$$

$$\partial H_m / \partial t = \partial L / \partial \lambda_{Hm} \quad \text{equation of motion for the state variable } H \text{ for husband} \quad (59)$$

$$\partial H_f / \partial t = \partial L / \partial \lambda_{Hf} \quad \text{equation of motion for the state variable } H \text{ for wife}$$



$$\partial H_c / \partial t = \partial L / \partial \lambda_{Hc} \quad \text{equation of motion for the state variable } H \text{ for child}$$

$$\partial W / \partial t = \partial L / \partial \lambda_W \quad \text{equation of motion for the state variable } W$$

$$\partial \lambda_{Hm} / \partial t = -\partial L / \partial H_m \quad \text{equation of motion for } \lambda_{Hm}$$

$$\partial \lambda_{Hf} / \partial t = -\partial L / \partial H_f \quad \text{equation of motion for } \lambda_{Hf}$$

$$\partial \lambda_{Hc} / \partial t = -\partial L / \partial H_c \quad \text{equation of motion for } \lambda_{Hc}$$

$$\partial \lambda_W / \partial t = -\partial L / \partial W \quad \text{equation of motion for } \lambda_W$$

To make calculations easier to read m, f and c are substituted by j (j=m,f,c) in some equations:

$$\lambda_{Hm}[I_m - \delta_m H_m] = \lambda_{Hf}[I_f - \delta_f H_f] = \lambda_{Hc}[I_c - \delta_c H_c] = \lambda_{Hj}[I_j - \delta_j H_j]$$

$$M_m = M_f = M_c = M_j$$

From the interior F.O.C. follow:

$$\partial L / \partial M_j = \lambda_{Hj} \partial I_j / \partial M_j - \lambda_W p = 0 \quad (60)$$

From equation (36)  $\lambda_{Hj}$  is found:

$$\lambda_{Hj} = \lambda_W p \partial M_j / \partial I_j = \lambda_W \pi_j \quad (61)$$

Like in previous model there is a substitution of  $p \partial M_j / \partial I_j$  by  $\pi_j$ .

$$\partial \lambda_{Hj} / \partial t = \partial \lambda_W \pi_j / \partial t + \lambda_W \partial \pi_j / \partial t \quad (62)$$

$$\partial L / \partial X = e^{-\theta t} \partial u / \partial Z \partial Z / \partial X - \lambda_W v = 0, \quad (63)$$

where  $Z = Z(X, h_{Z,i}; E_{H,m}, E_{H,f})$ .

$$\partial L / \partial \varphi_m = \Omega - h_{\omega,m} - h_{Z,m} - h_{Hm,m} - h_{Hf,m} - h_{c,m} - h_{S,m} - h_{Sc,m} = 0 \quad (64)$$

$$\partial L / \partial \varphi_f = \Omega - h_{\omega,f} - h_{Z,f} - h_{Hm,f} - h_{Hf,f} - h_{c,f} - h_{S,f} - h_{Sc,f} = 0 \quad (65)$$

$$\partial L / \partial \lambda_{Hj} = I_j - \delta_j H_j \quad (66)$$

$$\partial L / \partial W = \lambda_W r = -\partial \lambda_W / \partial t \quad (67)$$

$$\partial L/\partial \lambda_W = rW + \omega_m h_{\omega,m} + \omega_f h_{\omega,f} + B - p(M_m + M_f + M_c) - vX \quad (68)$$

$$\partial L/\partial H_i = e^{-\theta t} \partial u/\partial H_i - \lambda_{Hi} \delta_i + \lambda_W h_{\omega,i} \partial \omega_i/\partial H_i - \varphi_i \partial h_{s,i}/\partial H_i = -\partial \lambda_{Hi}/\partial t, \quad i=m,f \quad (69)$$

$$\partial L/\partial H_c = e^{-\theta t} \partial u/\partial H_c - \lambda_{Hc} \delta_c - \varphi_m \partial H_{Sc,m}/\partial H_c - \varphi_f \partial h_{Sc,f}/\partial H_c = -\partial \lambda_{Hc}/\partial t \quad (70)$$

Equations (61) and (62) are set to equation (70) and changed  $j$  into  $c$ :

$$e^{-\theta t} \partial u/\partial H_c - \lambda_W \pi_c \delta_c - \varphi_m \partial H_{Sc,m}/\partial H_c - \varphi_f \partial h_{Sc,f}/\partial H_c = -(\partial \lambda_W \pi_c/\partial t + \lambda_W \partial \pi_c/\partial t) \quad (71)$$

Into equation (71) is set equation (67) and the whole equation is divided by  $\lambda_W$ :

$$(e^{-\theta t}/\lambda_W) \partial u/\partial H_c - \pi_c \delta_c - (\varphi_m/\lambda_W) \partial H_{Sc,m}/\partial H_c - (\varphi_f/\lambda_W) \partial h_{Sc,f}/\partial H_c = r\pi_c - \partial \pi_c/\partial t \quad (72)$$

All  $\pi_c$  terms are moved to the right, and the solution to the parents-child problem is:

$$(e^{-\theta t}/\lambda_W) \partial u/\partial H_c - (\varphi_m/\lambda_W) \partial H_{Sc,m}/\partial H_c - (\varphi_f/\lambda_W) \partial h_{Sc,f}/\partial H_c = r\pi_c + \pi_c \delta_c - \partial \pi_c/\partial t \quad (73)$$

rewriting the equation (73) gives:

$$(e^{-\theta t}/\lambda_W) \partial u/\partial H_c - (\varphi_m/\lambda_W) \partial H_{Sc,m}/\partial H_c - (\varphi_f/\lambda_W) \partial h_{Sc,f}/\partial H_c = \pi_c(r + \delta_c - (\partial \pi_c/\partial t)/\pi_c). \quad (74)$$

To get the marginal condition equation (74) is rearranged and the optimal condition is used, (equation (48) from the husband-wife model, where  $i=m,f$ ); the marginal utility is left of the health on the left side and the rest put on the right side and the expression (48) for parents is divided by expression (74) for child:

$$\begin{aligned} (e^{-\theta t}/\lambda_W) \partial u/\partial H_c &= \pi_c(r + \delta_c - (\partial \pi_c/\partial t)/\pi_c) + (\varphi_m/\lambda_W) \partial H_{Sc,m}/\partial H_c + (\varphi_f/\lambda_W) \partial h_{Sc,f}/\partial H_c \\ \frac{(e^{-\theta t}/\lambda_W) \partial u/\partial H_i = \pi_i(r + \delta_i - (\partial \pi_i/\partial t)/\pi_i) - h_{\omega,i} \partial \omega_i/\partial H_i + (\varphi_i/\lambda_W) \partial h_{s,i}/\partial H_i}{(e^{-\theta t}/\lambda_W) \partial u/\partial H_c = \pi_c(r + \delta_c - (\partial \pi_c/\partial t)/\pi_c) + (\varphi_m/\lambda_W) \partial H_{Sc,m}/\partial H_c + (\varphi_f/\lambda_W) \partial h_{Sc,f}/\partial H_c}, & \\ & \quad i=m,f \quad (75) \end{aligned}$$

the equation (75) is reduced by  $(e^{-\theta t}/\lambda_W)$ , and the marginal condition is:

$$\frac{\partial u/\partial H_i}{\partial u/\partial H_c} = \frac{\pi_i(r + \delta_i - (\partial \pi_i/\partial t)/\pi_i) - h_{\omega,i} \partial \omega_i/\partial H_i + (\varphi_i/\lambda_W) \partial h_{s,i}/\partial H_i}{\pi_c(r + \delta_c - (\partial \pi_c/\partial t)/\pi_c) + (\varphi_m/\lambda_W) \partial H_{Sc,m}/\partial H_c + (\varphi_f/\lambda_W) \partial h_{Sc,f}/\partial H_c}. \quad (76)$$

Net effective marginal cost of adult health capital is the same as in equation (52). Net effective marginal cost of child health is equal to the user cost of child health capital less the marginal investment benefit of child health, which is the sum of the monetary value of the change in time taking care of a sick child for father and mother, respectively, for a marginal change in child health.

Equation (53) extends to:

$$\lambda_W = \lambda_{Hm}/\pi_m = \lambda_{Hf}/\pi_f = \lambda_{Hc}/\pi_c, \quad (77)$$

implying that the family invests in health until the rate of marginal utilities of (lifetime) health to effective price of health for all family members is equal and equal to marginal utility of wealth. The family will not try to equalize the amount of health capital between family members.

Rearranging the equation (77) gives:

$$\lambda_{Hc} = \lambda_W \pi_c, \quad (78)$$

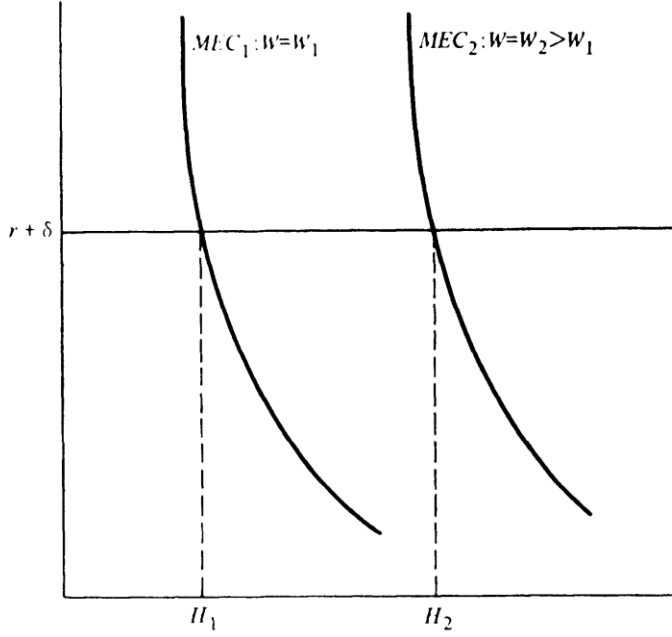
what means that poor families value a marginal change of child health higher than rich families. In the family where parents are unhealthy is expected that child health is lower than in “healthy parents”-family.

### 3.1 Wage effect

This effect is calculates by Grossman (1972).

It was discussed previously that the wealthier the individual more he can invest into his health. The less days spent sick mean that the individual can spend more days on market and nonmarket activities and increase his utility. Thus, the wage rate is positively correlated with the benefits of a reduction in the time individual loses from the production of money earnings due to sickness and the benefits from a reduction in time lost from nonmarket production are also positively correlated with the wage.

Figure 1 shows the shift of demand curve (MEC) when the wage increases from  $W_1$  to  $W_2$ , where  $r+\delta$  is the cost of health capital.

**Figure 1**

Source: Grossman M (1972) On the Concept of Health Capital and the Demand for Health. Journal of Political Economy, 80(2): 223-255

The figure 1 shows that when the wage increases, the MEC shifts to the right, from  $MEC_1$  to  $MEC_2$ , the demand for optimal health stock grows from  $H_1$  to  $H_2$ , while the cost of health capital stays the same. The wage elasticity of health capital is:

$$e_{H,W} = (1-K)\epsilon, \quad (79)$$

where  $K$  is the fraction of the total cost of gross investment accounted for by time, and  $\epsilon$  is elasticity of MEC schedule. The wage elasticity is larger, the larger the elasticity of the MEC schedule and the larger the share of medical care in total gross investment cost.

The increase in wage also has an effect of increasing the demand for medical care. The wage elasticity of medical care is:

$$e_{M,W} = K\sigma_p + (1-K)\epsilon, \quad (80)$$

where  $\sigma_p$  is the elasticity of substitution between medical care and own time in the production of gross investment. The greater the value of  $\sigma_p$ , the greater the difference between the wage elasticities of medical care and health stock.

To find the elasticity few more assumptions to the basic individual's health stock model are made.

The production functions are assumed to be homogenous of degree one in both goods and time inputs, so the gross investment function can be written as:

$$I_t = M_t g(\tau_t; E_t), \quad (81)$$

where  $\tau_t = h_{t,H}/M_t$ . The marginal products of time and medical care in the production of gross investment in health are:

$$\frac{\partial I_t}{\partial h_{t,H}} = \frac{\partial g}{\partial \tau_t} = g', \quad (82)$$

$$\frac{\partial I_t}{\partial M_t} = g - \frac{\partial I_t}{\partial M_t} \tau_t g'. \quad (83)$$

To get the wage elasticities of medical care and the time spent producing health Grossman (1972) partially differentiate three equations with respect to the wage:

$$I(M, h_{t,H}, E) = M g(\tau; E) = (\tilde{H} + \delta)H, \quad (84)$$

$$w = \rho g' \quad (85)$$

$$p = \rho(g - \tau g'), \quad (86)$$

where  $\tilde{H} = \frac{\partial H_t}{\partial t}$  is the stock of health over the life cycle,  $\rho$  is the marginal cost of gross investment in health,

$$\rho = \frac{p_t}{g - \tau_t g'} = \frac{w_t}{g'}. \quad (87)$$

Because  $I$  is linear homogenous in  $M$  and  $h_{t,H}$ ,

$$\frac{\partial(g - \tau g')}{\partial M} = - \frac{\tau \partial(g - \tau g')}{\partial h_{t,H}}, \quad (88)$$

$$\frac{\partial g'}{\partial h_{t,H}} = - \frac{1}{\tau} \frac{\partial(g - \tau g')}{\partial h_{t,H}}, \quad (89)$$

$$\sigma_p = \frac{\partial(g - \tau g') g'}{I \left\{ \frac{\partial(g - \tau g')}{\partial h_{t,H}} \right\}}, \quad (90)$$

where  $\sigma_p$  is elasticity of substitution between medical care and own time in the production of gross investment.

Therefore:

$$\frac{\partial(g - \tau g')}{\partial M} = - \frac{\tau(g - \tau g') g'}{I \sigma_p}, \quad (91)$$

$$\frac{\partial g'}{\partial h_{t,H}} = - \frac{1}{\tau} \frac{\partial(g - \tau g') g'}{I \sigma_p}, \quad (92)$$

$$\frac{\partial(g - \tau g')}{\partial h_{t,H}} = \frac{(g - \tau g') g'}{I \sigma_p}. \quad (93)$$

After carrying out the differentiation:

$$g \frac{dh_{t,H}}{dw} + (g - \tau g') \frac{dM}{dw} = - \frac{H(\tilde{H} + \delta) \varepsilon}{\rho} \left( \frac{d\rho}{dw} - \frac{\rho}{w} \right), \quad (94)$$

where  $\varepsilon$  is elasticity of the MEC (the shift of demand curve).

$$I = g' \frac{d\rho}{dw} + \rho \left( \frac{\partial g'}{\partial TH} \frac{dh_{t,H}}{dw} + \frac{\partial g'}{\partial M} \frac{dM}{dw} \right), \quad (95)$$

$$0 = (g - \tau g') \frac{d\rho}{dw} + \pi \left[ \frac{\partial (g - \tau g')}{\partial h_{t,H}} \frac{dh_{t,H}}{dw} + \frac{\partial (g - \tau g')}{\partial M} \frac{dM}{dw} \right]. \quad (96)$$

With the help of cost-minimization conditions and equation (93) and rearranging terms:

$$I\varepsilon \frac{d\rho}{dw} + w \frac{dh_{t,H}}{dw} + p \frac{dM}{dw} = \frac{I\varepsilon \rho}{w}, \quad (97)$$

$$I\sigma_p \frac{d\rho}{dw} - \frac{1}{\tau} p \frac{dh_{t,H}}{dw} + p \frac{dM}{dw} = I \frac{\rho}{w} \sigma_p, \quad (98)$$

$$I\sigma_p \frac{d\rho}{dw} + w \frac{dh_{t,H}}{dw} - \tau w \frac{dM}{dw} = 0. \quad (99)$$

To solve  $\frac{dM}{dw}$  in equation (99) Cramer's rule can be applied):

$$\frac{dM}{dw} = \frac{\begin{vmatrix} I\varepsilon + w + \frac{I\varepsilon \rho}{w} \\ I\sigma_p - \left(\frac{1}{\tau}\right)p + I\frac{\rho}{w}\sigma_p \\ I\sigma_p + w - 0 \end{vmatrix}}{\begin{vmatrix} I\varepsilon + w + p \\ I\sigma_p - \left(\frac{1}{\tau}\right)p + p \\ I\sigma_p + w - \tau w \end{vmatrix}}. \quad (100)$$

The determinants are:

$$dM = \frac{I\sigma_p}{h_{t,H}M} (I\rho\sigma_p h_{t,H}M + I\rho\varepsilon \frac{p}{w} M^2). \quad (101)$$

$$dw = (I\sigma_p \rho^2 I^2) / h_{t,H}M \quad (102)$$

Therefore:

$$\frac{dM}{dw} = \frac{h_{t,H}M}{I\rho} \left( \sigma_p + \frac{\varepsilon p M}{w h_{t,H}} \right). \quad (103)$$

In elasticity notation, it becomes:

$$e_{M,w} = K\sigma_p + (1-K)\varepsilon. \quad (104)$$

To find  $e_{h_{t,H},w}$  the same calculations as previously are done. To solve  $\frac{dh_{t,H}}{dw}$  in equation (99) Cramer's rule can be applied):

$$\frac{dh_{t,H}}{dw} = \frac{\begin{vmatrix} I\varepsilon + p + \frac{I\varepsilon\rho}{w} \\ I\sigma_p + p - I\frac{\rho}{w}\sigma_p \\ I\sigma_p - \tau w + 0 \end{vmatrix}}{\begin{vmatrix} I\varepsilon + w + p \\ I\sigma_p - \left(\frac{1}{\tau}\right)p + p \\ I\sigma_p + w - \tau w \end{vmatrix}}. \quad (105)$$

And it is found:

$$e_{h_{t,H},w} = (1-K)(\varepsilon - \sigma_p). \quad (106)$$

### 3.2. The Role of Human Capital

This effect is also calculates by Grossman (1972).

The education has an important role for an individual, better educated people are usually earning more than people without education. Also education changes the productivity in the households and in the market. Deaton (2016) assumes that better educated people usually have better health; there are less alcoholic drinkers and smokers. Maybe it caused that people have access to the health related information and make rational choices.



Grossman (1972) proposes that education improves nonmarket productivity. From the basic model follows that the index of human capital ( $E$ ) would be:

$$\frac{\partial I}{\partial E} = M \frac{\partial(g - tg')}{\partial E} + h_{t,H} \frac{\partial g'}{\partial E}, \quad (107)$$

where  $g - tg'$  is the marginal product of medical care and  $g'$  is the marginal product of time. The equation can be rewritten as:

$$r_H = \frac{\partial I}{\partial E} \frac{1}{I} = \left[ \frac{M(g - tg')}{I} \right] \left( \frac{g\hat{g} - tg'\hat{g}'}{g - tg'} \right) + \left( \frac{h_{t,H}g'}{I} \right). \quad (108)$$

Equation (108) indicates that the percentage change in gross investment supplied to a consumer by a one-unit change in  $E$  is a weighted average of the percentage changes in the marginal products of  $M$  and  $h_{t,H}$ .

The percentage in the marginal products of medical care and own time for a one-unit change in human capital:

$$\frac{\partial(g - tg')}{\partial E} \frac{1}{g - tg'} = \frac{g\hat{g} - tg'\hat{g}'}{g - tg'}, \quad (109)$$

$$\frac{\partial g'}{\partial E} \frac{1}{g'} = \hat{g}'. \quad (110)$$

If a shift in human capital is “factor neutral”, what means the education has a “neutral” impact on the marginal products of all factors. :

$$\hat{g} = \frac{g\hat{g} - tg'\hat{g}'}{g - tg'} \quad (111)$$

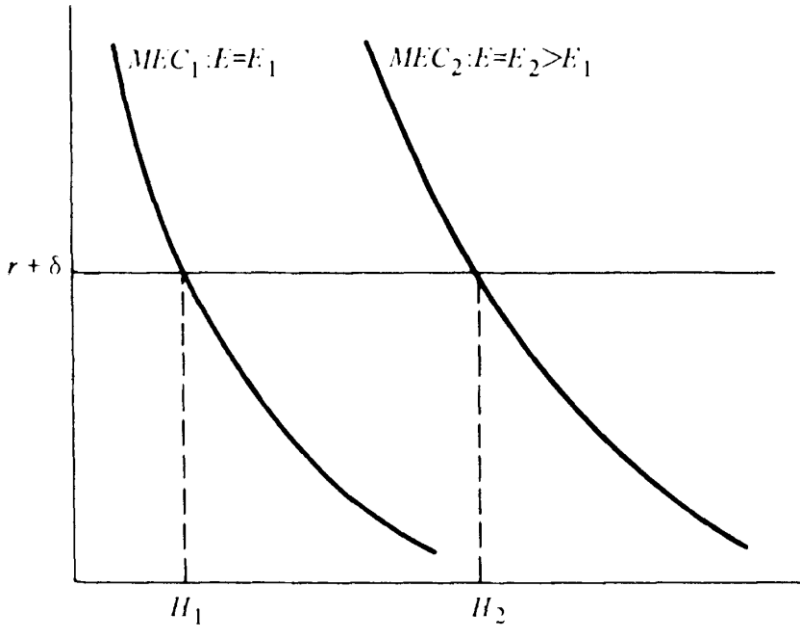
If education increases productivity, then  $r_H > 0$ , and equation (108) can be simplified to:

$$r_H = \hat{g} = \hat{g}'. \quad (112)$$

If education increases the marginal products of medical care and own time by certain percent, it would reduce the price of gross investment by the same percent.

Figure 2 shows the effect of increase in education. It would raise the marginal efficiency of health capital and shift the MEC schedule to the right, from  $MEC_1$  to  $MEC_2$ , the demand for optimal health stock grows from  $H_1$  to  $H_2$ , while the cost of health capital stays the same.

**Figure 2**



Source: Grossman M (1972) On the Concept of Health Capital and the Demand for Health. Journal of Political Economy, 80(2): 223-255

The percentage increase in the amount of health demanded for a one-unit increase in E is given by

$$\hat{H} = r_H \epsilon. \quad (113)$$

The average cost of gross investment in health is:

$$\tilde{\pi} = (PM + Wh_{t,H})I^{-1} = (P + Wt)g^{-1}. \quad (114)$$

Given factor neutrality,

$$\frac{d\tilde{\pi}}{dE} \frac{1}{\pi} = -g = -r_H. \quad (115)$$

Therefore,

$$\pi = P(g - tg')^{-1}, \quad (116)$$

and

$$\frac{d\pi}{dE} \frac{1}{\pi} = -\left(\frac{g\hat{g} - tg'\hat{g}'}{g - tg'}\right) = -\hat{g}' = -\hat{g} = -r_H. \quad (117)$$

Taking the total derivative of  $E$  in the gross investment function:

$$\frac{dI}{dE} \frac{1}{I} = M \frac{(g - tg')}{I} M + \frac{h_{t,H}g'}{I} h_{t,H} + r_H. \quad (118)$$

Because  $\hat{M} = \widehat{h_{t,H}}$  and  $\hat{H} = \hat{I}$ :

$$\hat{H} = \hat{M} + r_H. \quad (119)$$

Because  $r_H$  indicates the percentage increase in gross investment supplied by a one-unit increase in  $E$ , shifts in this variable would not alter the demand for medical care or own time if  $r_H$  equaled  $\hat{H}$ . Any effect of a change in  $E$  on the demand for medical care or time reflects a positive or negative difference between  $\hat{H}$  and  $r_H$ :

$$\hat{M} = \hat{h_{t,H}} = r_H(\varepsilon - 1). \quad (120)$$

Grossman (1972): “Equation (120) suggests that, if the elasticity of the MEC schedule were less than unity, the more educated would demand more health but less medical care”.

#### **4. Literature review on the factors increasing the health**

There are several researches about the factors influencing health and wealth. Most of them study the effect of childhood health and education on future income and health. Smith (2007) found that better health in childhood is related to higher income, higher wealth, more weeks worked and a higher growth rate of income.

##### **4.1 Education**

Strulik (2018) had studied the effect of return to education in terms of wealth and health. Strulik assumed that every individual had 9 obligatory years of school and studied how the additional year of schooling would effect on health. He also discussed that the less educated individuals are more likely to spend money on unhealthy products (such as alcohol and tobacco), than educated. He concluded that the individuals who care about their health decrease the unhealthy consumption and increase spending in health. Strulik had done several experiments. One of the experiments shows the result that the additional year of education changes behavior: the person increases the health expenditures and decreases the unhealthy consumption. It means that the additional year of education increases the expectancy of life. He also found that the more educated individuals demand more health services and benefit more from the medical technological progress.

Oreopolus (2007) studied the effect on health from compulsory schooling. He also found out that the compulsory schooling increases the life-expectancy. According to his results the year of compulsory schooling decreases the probability of reporting being in poor health. Compulsory schooling also lowers the chance of being unemployed and increases the probability of likelihood of being satisfied with life. He concludes that “lifetime wealth increases by about 15% with an extra year of compulsory schooling.”

Grossman (2015) had studied the relationship between infant mortality and education. He found that the schooling coefficient is negative and statistically significant, what helps to “explain” the decrease in infant mortality and increase in life-expectancy between the years 1910-2000.

Grossman discussed different health studies and collected the important results, for example, that the women in poor countries with more education have less sexual partners and more likely to use contraception.

## 4.2 Social Status and Wage

Demakakos et al. (2008) studied the role of subjective social status (SSS). Subjective social status means where the individual places himself in the social hierarchy. Demakakos et al made an analysis using cross-sectional data from the second wave (2004-2005) of English Longitudinal Study of Ageing. The measures were subjective social status, objective social status (which included education, occupational class and wealth), sociodemographic characteristics (age and marital status) and health outcome (self-rated health, long-lasting illness or disability, depression, hypertension, diabetes, central obesity, HDL-cholesterol, triglycerides, fibrinogen, and C-reactive protein). The results showed that individuals who reported the lower SSS had worse health. Also it was found that wealth is more related with SSS than occupational class or education. The main result of this paper is that SSS is related to self-rated health and mental health. Euteneur (2014) reviewed the works on relation between SSS and health. He also concluded that SSS is related to self-rated health and mental health.

Karvonen and Rahkonen (2011) studied the relations between SSS and health among the youth. They collected data at the Finnish schools from 8<sup>th</sup>-9<sup>th</sup> graders through questionnaires. The questions included the highest educational level of one of the parents, the occupational status of the parents, the amount of pocket money the pupil gets, the performance at school, how the pupil put the family on the social ladder (SSS), self-rated health, long-lasting illnesses and mental health. The results also showed that the pupils who put their families on the top of social ladder had the better health. Karvonen and Rahkonen also found that SSS is related with parents' level of education, with school performance, with weekly money allowance, and with parents' employment status.

Komro et al (2016) studied the effect of increasing minimum wage on infant mortality and birth weight. The research included data from the United States. Komro et al (2016): "We estimated the effects of state-level minimum wage using a quasiexperimental difference-in-difference research design." The result is that one dollar increase in wage decreases the low birth weight births by 1-2% and decreases the infant postneonatal mortality by 4%.

### 4.3 Early Childhood, Family and Nutrition

All the researches were collected and discussed by Currie (2009).

Currie (2009) studied how parents' socioeconomic status affects health of child and does health in childhood affects future educational and market outcomes. Currie showed that wealthier parents are able to buy more or better quality health inputs, like safer toys, medical care, housing, and neighborhoods. It is discussed that the difference in health between poor children and rich children grows with the age. The poor children recover slower and the probability to get a chronic disease is higher for them, also low SES acts as a stressor and leads to mental health problems. The disease, like asthma, causes more problems to poor children, because they are less likely to manage properly their disease. The children from low income families are less likely to be properly diagnosed because of lack of medical attention. Rich and poor parents have different view on the injuries which require the medical assistance; it can be seen as one of the reasons of higher rate of children death in low income families. The risk of obesity is higher for poor children than for rich.

Currie wrote that the poor child health will affect future health, what can affect the labor supply and productivity. The low socioeconomic status in childhood will affect the health also in the future, even if the individual gets the higher socioeconomic status. Children from poor families are less willing to get education what affects their future income. Health in utero is related with birth weight and metabolism, the unhealthy consumption of mother can lead to brain damage or birth trauma. Low birth weight babies have lower scores at school and on intellectual and social development tests; they also have lower probability to be employed as of age 33, same results are as of age 42.

Currie discussed the fetal origins, what means that the exogenous shock caused by conditions outside the control of mother. One of the examples is famine in the Netherlands during the Second World War, which is known as "Dutch Hunger Winter". The babies who were in utero during that period are more likely to get health impairments, including disorders of central neural system, heart diseases and antisocial personality disorders. Maternal diseases during the pregnancy have also a negative influence on babies causing health impairments. It was also found that children who were infected in utero are less likely to graduate from high school; they are more likely to get low socioeconomic status due to health disabilities. The same results are in case when mothers drank

alcohol being pregnant. The experiments showed that negative shocks to health in utero have significant effects on the future health and socioeconomic status.

Another effect discussed by Currie is birth weight. It was found that babies who had higher birth weight are taller and get more schooling. Low birth children are less likely to graduate from high school. It was found that increasing in birth weight would decrease infant mortality, and for the higher birth weight the increase in weight will reduce hospital costs. Low birth weight has significant effect on the future socioeconomic status.

Nutrition plays a crucial role in achieving the higher socioeconomic status in the future. It was studied in the developing countries, that the children who had better nutrition were more likely to complete the education and to have higher cognitive abilities. Nutrition in childhood affects the height, and it is discussed that there is a robust relationship between adult height and earnings.

Mental health problems in childhood strike in the future, the individual loose the income being out of work place. Children with mental health problems are less likely to finish the high school or to attend the college. They have lower grades at school and it leads to a lower chance to be employed in the future. Currie writes: “The available evidence suggests that “externalizing conditions” such as ADHD (Attention Deficit Hyperactivity Disorder) or aggression have more significant consequences for outcomes such as completed education and earnings than internalizing conditions.”

Table 8 copied from Currie (2009) and summarizes the evidence linking several different domains of child health to outcomes. The researches were made using the data from U.S. CDC stands for Centers for Disease Control, BMI is for Body Mass Index, PIAT is the Peabody Individual Achievement Test, and SD is score distribution.

## **5. Conclusions**

In this paper I tried to show the connection between wealth in health. From the previous sections it can be seen that they are related. It is seen that through health wealth can be increased. When it is known which factors affect health then it is easier to think about the policies.

**Table 8****Disease Prevalence and Effects**

|                       | Overall Prevalence   | Poor vs. Non-Poor Rate   | Effect  |
|-----------------------|--|--|---|
| ADHD                  | 4,19% boys, 1,77% girl (Cuffe, Moore, and McKeown 2005)  | 6,52% vs. 3,85% (Cuffe, Moore, and McKeown 2005)   | 0,26 SD reduction in PIAT Math, 0,32 SD reduction in PIAT reading in adolescent children (Currie and Stabile 2006)  |
| Asthma                | 13% diagnosed<br><br>6% attack in past 12 months (Bloom 2003)  | 15,8 vs. 12% (Bloom 2003)<br><br>33,2 vs. 20,8% have limitations (Akinbami, LaFleur, and Schoendorf) | Doubles odds of behavior problems (Bussing et al. 1995)<br><br>7,6 days absent vs. 2,5 for nonasthmatic children, 9% have learning disabilities vs. 5% nonasthmatic, 18% repeated grades vs. 12% nonasthmatic (Fowler et al. 1992). Are effects causal? |
| Lead Poisoning        | 2,2% have blood lead above CDC standard in 99/00 (CDC web site)  | ~60% of children w confirmed high lead levels are Medical eligible (Meyer at al. 2003)               | Increase from 10 to 20 microg/DL reduces IQ scores by 2-5 points (c.f., Pocock, Smith, and Baghurst 1994)   |
| Other toxic exposures | Unknown  | Unknown  | Unknown   |
| Obesity               | 31% at risk/overweight<br><br>16% overweight (Hedley et al. 2004)  | BMI>85%tile 3.4 pp more likely on a base of 8,9% (Bhattacharya and Currie 2001)                      | Higher rates of adult disease, but exact magnitudes controversial.<br><br>Effects on schooling attainment?  |
| Anemia                | 9% toddlers iron deficient, 3% anemic (Looker et al. 1997)   | Poor children 50% more likely to be deficient (Looker et al. 1997)                                   | Long-term supplementation of anemic children improves cognitive functioning, but no evidence that supplementation of deficient children has effects. Given low rates of anemia, effects on disparities in school readiness may be small.                |
| Injuries              | Unintentional = 16,5 per 100 000; Intentional = 6,5 per 100 000 in 1998 all children 0-19 (Currie and Hotz 2004) | Poor children 2-3 times more likely to die (Singh and Yu 1996)                                       | Unknown.  |

Source: Currie J (2009) Healthy, Wealthy, and Wise: Socioeconomic Status, Poor Health in Childhood and Human Capital Development. *Journal of Economic Literature*, 47(1): 87-122



For example, redistribution of wealth is not seen as the best policy, because it is not Pareto efficient. Redistribution will improve the wealth of low-income group, but reduces the wealth of high-income group, in total it can be seen that the health of nation stays at the same level, because the loss of health among the rich will be offset against the gains among the poor.

Grossman model modified by Jacobson shows that health can be viewed as a durable capital stock where individual can invest in. Partners can invest in to the health of each other, and parents can invest in health of a child. Jacobson model suggests that there should be different types of families taken into account when the policies are made.

One of the discussions of this paper is that the fetal health is very important. The improving of health should include the protection of the health of mothers. The health of child is important not only for its own sake but it brings a large payoff in terms of future human capital accumulation. Education is one of the factors that affects both wealth and health, improving the education and making it accessible for all leads to a better health and wealth conditions. Also new technological innovations and medical innovations will increase the health. Better access to the medical service and information would also increase the health.

Improvements in health will not only increase the wealth of an individual, but it leads to economic growth. There should be more studied which policies could help to improve the unhealthy children opportunities and how to prevent the affect of past low socioeconomic status on future.

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